# Constructional element and method for its manufacture

The present invention concerns a constructional element intended for building with logs with cogged joints, hereinafter generally referred to as notching, as well as a method for the manufacture of such element.

The invention further concerns a method for the manufacture of a structural element intended to be part of a constructional element according to the first aspect of the invention, or in other constructional elements. The structural element may also be used as an independent product.

**Background**

It is an old tradition to raise buildings with timber logs. In recent years this tradition has mainly been upheld with respect to building of cabins/ leisure buildings. Cabins with cogged joints are generally seen to be particularly beautiful. Building with this tradition is, however, not free of problems.

A disadvantage with notching of cabins/ buildings in real timber is the high requirement of premium quality timber. Such timber is today a scarce resource and the buildings therefore become expensive. Another disadvantage is the specific thermal insulation. Compared to well insulated buildings of modern construction, the thermal insulation is significantly poorer. In a Nordic climate, notched buildings that are not provided with an internal insulation is not suited for use all year, and is quite uneconomical also for cabin use.

A third disadvantage is related to the fact that buildings in timber logs sinks several per cents (cm per meter height) the first years, which leads to severe problems with respect to maintaining tight doors, doors that do not get jammed and to maintain leakage free roof openings for pipes and ventilation.

On this basis and on the basis of a need for a more extensive use of recycle material in building production, attempts have been made with respect to make a constructional element that looks like real timber but consists of an internal, insulated core and a wooden or wood-like "shell".

Norwegian patent No. 311 583 describes timber-like elements for notching where each side of the elements is comprised by several (e.g. 3) joined panel elements that are profiled in a manner so that their outer sides subsequent to the joining appear as substantially continuous, convex surfaces. Between these joined panel elements spacer elements are

arranged that serve to hold the panels in a steady, unchanged mutual distance from each other. The same spacer elements serve to give the entire building its required strength. The void between the outer parts is intended to be filled with a thermally insulating material, e.g. polyurethane. Near the ends the elements are provided with recesses for notching. The construction has the disadvantage that preparing and assembling of each timber-like element from individual panels and spacers is a comparatively complex process.

Swedish laid-open publication No. 457 456 describes a "timber-element" with outer tree panels provided with longitudinal groves, where the spacers are arranged in the groves. The void between the panels and the spacers are also in this construction intended to be filled with a thermally insulating material like foamed polyurethane. Holes are arranged in certain positions of the spacers so that rods 8 may be positioned (vertically) through the holes in each element of a completed wall, whereby said rods may constitute the weight carrying elements of the wall. Like for the construction discussed above, this construction comprises a lot of components that need to be adapted to each other. It is quite a "puzzle" work to put together one single timber element from its separate components.

US patent No. 4,433,519 describes a hollow, cylindrical prefabricated constructional element intended for the same use as the above mentioned publication. Here it is assumed that the convex outer surfaces are comprised either by glass fibre, metal, plastic or moulded wooden products with the required structural integrity. The outer panels are thus not made in a natural wooden material. Flanges at the upper and lower side of the constructional elements are arranged to overlap when the elements are placed on top of each other, and they are provided with holes so that bolts or the like may be inserted through the elements to lock the elements together. Like the previously discussed constructions this one also comprises spacer elements that are arranged at certain intervals along the elements, but here the prefabricated elements themselves are designed to carry most of the weight load. The void between the elements is preferably filled with a thermally insulating material. This construction has the advantage over the previous ones that it is assembled from fewer components but on the other hand the side panels are not in "whole wood".

Swedish laid-open publication No. 440 250 describes still another product intended for notching, and it constitutes outer wooden panels with inner spacers that are attached to the side panels by means of longitudinal grooves in the latter. A wooden panel according to this publication does not comprise a convex outer surface. It is mentioned, however, that the edges may be chamfered to give a visual impression of such a convex surface.

**Objectives**

It is an object of the present invention to provide a constructional element and a method for the manufacture of such an element, which visually and in assembled state gives an optimal impression of notched timber logs.

It is thus an object of the present invention to provide a constructional element with convex outer surfaces in "whole wood", which may be manufactured in a quick and rational process.

It is furthermore an object to provide a constructional element of said type with the required volume for all thermal insulation in an inner void, and which is simple to insulate with conventional fibrous or foamed insulation materials before or after assembly to a building.

**The invention**

Said objects are achieved by a constructional element and the method according to the invention as further elaborated below.

According to a first aspect the invention concerns a constructional element as defined by claim 1 and a method for the manufacture of such an element as defined by claim 12. According to another aspect the invention concerns a structural element that constitutes a side wall of the constructional element according to the first aspect of the invention as defined by claim 18 and a method for the manufacture of such an element as defined by claim 22.

Preferred embodiments of the invention are disclosed by the dependent claims.

A central aspect of the present invention is the fact that the components constituting a constructional element are assembled in a simple and rational process that may be largely automatized. It is a further important aspect that said objects are achieved without compromising the aesthetical aspects of the product which has sides in whole wood. The process of making grooves on one side (the inside) of the boards removes tension in the boards and in addition the grooves provide a mechanical grip for the plastic material. By the option to "lock" the side edges of the boards when they are bent to a curved shape, a controllable degree of cracks are formed, thus making the boards look even more like real timber logs. It is an alternative to use a thermosetting plastic material instead of a thermoplastic material, requiring an alternative technique for application that is also described in detail.

Furthermore it is preferred that the side walls are based on panels of real (whole) wood, even though materials like fibreboard panels and other tree-like materials may also be used. It is also possible to use one material for the outside wall and a different material for the inside wall. It is even feasible to use an even simpler type of panel for the inner wall, e.g. one that is not convex and if it is not desired to give the impression of real timber logs inside, the panels for the inside walls may have a flat surface that subsequently may be covered with wall paper or the like. In this latter case a structural element manufactured as defined by claim 12 is used for the inside panel of the constructional element and a structural element manufactured as defined by claim 11 is used for the outside panel of the constructional element.

**Concrete embodiments of the invention**

The invention will now be described in further detail with reference to the enclosed drawings, wherein,

Fig. 1-6 show vital steps of the manufacture process for a constructional element.
Fig. 7 is a schematic illustration of the process comprising the steps shown in Figs 1-6.
Fig. 7b is an enlarged partial view of a variant of the process shown in Fig. 7.
Figs. 8 and 9 are two different side sectional views of a completed constructional element according to the present invention.
Fig. 10 is a sectional side view of a wall comprised by constructional elements according to the invention.
Figure 11 is a cross sectional view of two constructional elements of the invention, one placed on top of the other.
Figure 12 and 13 show steps of manufacture for parts of a constructional element according to the invention in a case where a thermosetting plastic material is used instead of a thermoplastic material.

Figure 1 shows an end view of a board 1 for forming a structural element that constitutes a side surface (wall) of a constructional element according to the invention. The side that is faced down will form an outside of the constructional element while the side that is faced up and provided with a number of longitudinal grooves 2, will form an inside of the constructional element.

Figure 2 shows the board of Fig. 1 at a stage where rolls (not all shown) on all sides of the board have begun to force the board into a curved shape in a direction cross the board's longitudinal direction.

Figure 3 shows the board in the final curved shape, in the manner it is fed into an extruder.

Figure 4 shows the board as emerging from the extruder. A thermoplastic material fills the grooves 2 in the board's inner (concave) side and forms a coating a few mm thick on this side. Close to the side edges of the board the same thermoplastic material forms two longitudinal flanges 4a and 4b whose function are explained below. Polypropylene and polyethylene are preferred thermoplastic materials and preferably high density polyethylene. PVC is also a well suited plastic material.

Figure 5 shows the board subsequent to having been furnished with a rib 5 in the still soft thermoplastic material on the concave side of the board 1. The rib 5 is sideways delimited by the flanges 4a and 4b. Such ribs 5 are arranged at even intervals in the longitudinal direction of the board. The term "rib" is used instead of "spacer" to emphasize that the function of the rib is to hold the board stable and curved, not merely to hold/ define the distance between the boards of a completed constructional element. A similar function is not included in any one of the previously known constructional elements, which is why these previous elements do not provide such a close resemblance to real timber logs. When using ribs that is cut from a single plate or board, it will be understood that the orientation of the rib on the board will be substantially perpendicular to the longitudinal direction (axis) of the board. When later referring to the "ends" of the ribs, the parts of the ribs close to the flanges 4a and 4b in Fig. 5 is what is meant.

As shown by Fig. 5 and 6 the ribs may have recesses 6 intended to be filled with additional thermoplastic material in a subsequent step (Fig. 6). Alternatively the ribs 5 are fully covered by a thin layer of thermoplastic material. Each rib is preferably furnished with two holes for reception of pegs corresponding to the pegs used in the furniture industry for assembly of furniture. The holes are preferably localized near each end of the ribs (near the longitudinal flanges 4a, 4b), and at a right angle with the longitudinal direction of the structural element, such that one and the same peg may be received by a hole in a rib attached to a structural element that forms part of an exterior wall surface and by a hole in a corresponding rib attached to a structural element that forms part of an internal wall surface,

thereby contributing in binding together the inner and the outer structural element of a constructional element.

Figure 7 shows the entire process schematically. Boards are fed from left in the Figure between pairs of rolls A. With reference to Figure 7 the entire process is described in relation to the treatment of a single board. Grooves 2 in the board 1 may be formed at an earlier stage but may conveniently be made at this stage of the process. The grooves may be solely longitudinal, as such grooves are the simplest to make, or they can have other shapes or patterns, such as a diamond-shaped pattern. Alternatively the grooves may be omitted. The rolls B causes an initial curving (bending) of the board as shown in Figure 2, while the board at the point of entering the extruder C has been given its final curved shape as shown in Figure 3. Prior to covering the board's concave side with plastics in the extruder, it is preferred to treat this side with an adhesive agent or a compatibilizer that makes the plastic material bind better to the wood. Such an adhesive agent may be maleic anhydride. As an alternative to the shown pair of rolls A and B the board may be fed by means of an articulated belt.

An endless belt 19 is furnished with fixtures 18 to which the ribs are temporarily attached. At point D the ribs are forced against the side of the board 1 that has been covered with a layer of thermoplastic material in the extruder. If the ribs are provided with holes the holes may be used for an exact positioning of the ribs relative to the board on which they are to be attached. Immediately thereafter, at the point E in Figure 7, each rib 5 receives thermoplastic material in through openings of the rib, fed to it in by injection moulding so that the thermoplastic material sticks to an inner surface of the rib as well as to the still soft thermoplastic material 3 on the board 1. Alternatively, as shown in Fig. 7b, each rib is forced against the board in an enveloping die 18' that follows the endless belt 19, and at point E a thermoplastic material is injected through a conduit 20 to cover the entire rib 5 completely with thermoplastic material. Figure 7b also shows how a layer of an adhesive agent 21 is fed to the board 1 immediately prior to the addition of thermoplastic material 3 in the extruder C.

Coolant air is blown over the thermoplastic material 3 and the ribs 5 at the point F so that the thermoplastic material sets and ensures a permanent attachment of the ribs to the board, thereby safeguarding a permanent curved shape of the latter. Alternatively water may be used as a coolant, by filling the voids between the ribs with water immediately subsequent

to the injection moulding. The water is sucked up again at the point where the product element (structural element) is about to leave the belt/ production station.

It is convenient to use wooden ribs as wood is quite dimensionally stable in the direction of the fibres, and maintains its shape even when exposed to severe temperature variations over a long time. It is most important that the ribs are dimensionally stable across the longitudinal direction of the constructional element, which will mean in the vertical direction for the common use if the elements. It is otherwise not required with any kind of refinement of the wood used for ribs, non-planed wooden boards may be used and it does not matter if there are knots or holes from knots in the boards. Also other materials may be used for the ribs, like steel, synthetic materials and composite materials, but it is hard to find materials with the positive properties of wood without adding costs to the production. When using steel ribs they may be provided with spikes that penetrate the board to which the rib is attached. When using a synthetic material or a composite material, the ribs may be dimensioned with a larger extension in the longitudinal direction of the board compared to when using steel or wooden ribs, without increasing the weight of structural element/ constructional element, as such ribs may be designed as non-compact structure.

When it is stated that a number of ribs are arranged with defined intervals, this usually means one fixed interval between each rib, even though from a productional point of view also other solutions may work equally well.

It will be recognized that with the method described above, which may be automatized and controlled by a CAD/ CAM system, completed side surfaces or panels for constructional elements may be fabricated in tailor-made dimensions that are limited only by the length of the boards fed to the process. With "completed side surfaces" is understood that the boards have received their final curved shape, the ribs provide the structure with strength and integrity and the thermoplastic material provide the structure a moisture barrier. The integral intermediate product thus formed constitutes what is also referred to as a structural element for the constructional element.

Figure 8 is a sectional view that illustrates how two side surfaces manufactured in accordance with the process of Figures 1-6 and 7 are assembled to make up a complete constructional element according to the invention. Attachment means 8 are mounted at upper and lower end of each rib or some of the ribs with screws or the like, and also to a pipe element 7. Each constructional element in one and the same wall will have such pipe

elements positioned straight above each other so that continuous rods may be inserted from the uppermost to the lowermost element of the wall in selected positions. This feature is more fully explained with reference to Figure 10.

It is preferred to use identical attachment means 8 in one and the same building or in one and the same wall. It should be noted, however, that by simply replacing the attachment means with some of another and larger horizontal dimension, a thicker constructional element is obtained which allows room for more thermally insulating material. It is thus not required to change the shape or dimension of the ribs to obtain a thicker constructional element. This is a feature of importance when comparing the present invention with constructional elements according to the prior art.

Figure 9 is a sectional view of a constructional element between to sets of ribs. Sealing tape or foil 9 up and down running the entire length of the constructional element, delimits the internal void of the constructional element, such that a preferably injected thermally insulating material 10, like mineral wool, is kept steady within the element.

Figure 10 is a sectional view of a wall 11 notched from constructional elements according to the invention. At even intervals along the length of the constructional elements pipe elements 7 suited to accommodate bolts or rods 14 are arranged as mentioned. Such bolts or rods typically extend through the entire height of the wall. Each bolt 14 preferably is provided with threads at both ends for simple attachment to an anchoring element 15 in the cement base 16 and (at upper end) e.g. a nut 17, possibly in combination with a washer (not shown).

In practice it is convenient that e.g. the lower end of each pipe element 7 has a conical tapered shape that fits into the upper end of a similar pipe element that protrudes somewhat from the constructional elements, such that the pipe elements during assembly of a wall are pushed into and slightly overlaps each other. In this way the pipe elements lock each constructional element to the adjacent element above and below with respect to any sideways movement. By tightening the nuts 17 with an appropriate torque a strong and reliable binding of each wall is achieved while the risk of a gradual sinking of the wall is as good as completely eliminated. Furthermore, as the constructional elements are very lightweight, they normally need to be secured to the base wall to avoid the risk of being blown away during very heavy winds.

It should be emphasized that it is also an alternative to replace the above mentioned pipe element by an element that on one hand is able to function as a connective element for the two structural elements constituting the side walls of the constructional element and on the other hand is able to work as a guide for vertical bolts through an assembled wall. Such alternative elements will be equivalent to the pipe elements described above even if they do not have the shape of a whole pipe.

The wall shown in Fig. 10 has a lower log or half-log 12 in solid wood and a corresponding upper log 13 in solid wood. It is not required with such solid wood logs, but it represents a preferred embodiment.

Figure 11 is a sectional view of two adjacent constructional elements which constitute part of a wall. The nethermost 2/3 of the sectional vies is within the body of rib 5 which is provided with holes into which pegs 22 are inserted to position the ribs 5 relative to each other in the pairs of oppositely arranged structural elements that form respective sides of a constructional element. It should be noted that in contradiction to Figure 8 no pipe element 7 or attachment means 8 is shown. Some of the pairs of ribs require a type of pipe element or the like that extends in the full height of the wall while other pairs of ribs 5 may be just as shown in Figure 11. The uppermost 1/3 of the sectional view is placed between the ribs and shows the insulating material 10 in the constructional element.

Figures 12 and 13 show process steps for the manufacture of structural elements of the invention where the plastic layer coated to the inside of the boards 1, is a layer of thermosetting plastics rather than thermoplastics. The choice of material requires that the manufacture takes place in a press shape mould instead of in an extruder (as shown in Figures 7 and 7b).

Figure 12 shows an open mould 23 with a lower part 23a and an upper part 23b, hinged about an axis 24. The upper part comprises a frame structure 24 that holds a hinged, three-part pressing profile 25a-c with a shape adapted to the shape of the structural elements to be manufactured. Between the frame 24 and the pressing profile 25 a-c are arranged hoses 26 for pressurized air. A board 1 is positioned I upper part 23b while ribs 5 and epoxy with reinforcement 3' are positioned in lower part 23a of the mould.

Figure 13 shows the forming of a structural element as the mould 23 has been closed and locked with hatch 27. The hoses 26 have been filled with pressurized air causing the hinged, three-part pressing profile, preferably made in aluminium, to apply a significant

downwards force to the entire board. The side of the board that was faced up in Figure 12 is now faced down and is pressed to an intimate contact with and thus binds to the epoxy resin 3' which is preferably reinforced with glass fibres. As most clearly seen from Figure 13 only the central part 25b of the three-part pressing profile 25 is rigidly connected to the frame structure 24, while the outer parts 25a, 25c of the pressing profile are hinged to the central part 25b with a certain degree of rotational freedom, such that the outermost edges of the outer parts 25a, 25c under influence of the hoses filled with pressurised air, in the closed condition of the mould are moved downwards until the curvature of the pressing profile 25 a-c corresponds to the curvature of the rib s 5.

With respect to the cogged joints, these are preferably not made as an integral part of the constructional element according to the invention. Rather the constructional elements are terminated with an open recess intended to receive separate cogging elements of the type described in Norwegian patent application No. 1996 3642.

When using separate cogging elements each constructional element is terminated as mentioned with an open end towards the joint. At the open end a pre-fabricated transition-element (not shown) will preferably be attached to the constructional element by means of "speilsveising" or the like. The outer profile of such a transition-element will have a profile corresponding to the internal profile of the constructional element while the inner profile of said transition-piece is a rectangular opening with a shape that corresponds to the outer profile of a cogging or splicing element. After attachment (welding) of the transition-element to the thermoplastic material inside the constructional element, the transition-element forms part of a sealed barrier that prevents moisture from entering the constructional element from an end of same.

When in this description there is made a distinction between a cogging element and a splicing element, this has to do with the fact that long (outer) walls are divided where an inner wall cross such outer walls. The separating inner wall will include a cogging element (also denoted end element) at the outside of and at a right angle to the outer wall, while a splicing element that is completely hidden by the constructional elements and the cogging joint, ties together two principally equal constructional elements of the outer wall that meet at the cogging joint. These cogging elements and splicing elements are described in Norwegian patent application No. 1996 3642 and do therefore not constitute part of the present invention. The splicing and cogging elements are preferably made in whole wood,

but particularly the splicing elements that after assembly are invisible, may also be made in other materials.

At terminations of walls towards windows and doors, the constructional element is terminated in an end-piece that in contradiction to the transition-element does not have any opening. The end-piece may, like the transition-element, be made as a prefabricated thermoplastic element. The manner for attachment to the rest of constructional element may be as for the transition-element, i.e. it may be welded to the thermoplastic material at the inside of the boards by means of "speilsveising" or the like. While otherwise visible parts of the transition elements are hidden by the cogging joints, the otherwise visible parts of the end-pieces are hidden behind a door frame, window frame or the like.

It is worth noticing that at delivery from a factory to a constructional site the constructional elements according to the invention will already be furnished with end-pieces and transition-elements as well as separate cogging elements where appropriate. It is also worth noticing that the constructional element according to the present invention does not comprise the cogging element.

Extrusion of the plastic material to the board represents a rate determining step of the manufacture process and a realistic speed for this process is about 1m per minute, which for a relevant log thickness corresponds to a production of 10 $m^2$ wall per hour or a normal sized cabin per day.

The list of advantages with the present invention is long.

Firstly the method of manufacture is simple and may readily be automated and is therefore inexpensive. A normal cabin may be drawn in A CAD system within an hour's time, be manufactured in 1-2 days and normally be delivered in less than 2 weeks.

Secondly the applied plastic material constitutes a diffusion proof barrier that prevents any moisture form entering the void of the thermally insulating material.

A third advantage is the design of the element's walls – with a curved shape that is mistakenly similar to solid logs.

A forth advantage is the weight. The constructional elements has a 1/3 weight of solid logs and still makes a strong wall construction when assembled. Only 1/3 of the wood needed for a timber cabin is consumed and the quality of the wood is less critical.

A fifth advantage is the thermal insulation, as the walls are easy to insulate and an entire wall may be insulated in one single operation with fibre or foam. Pre-fabricated constructional elements has three times the insulating ability of whole timber logs, and is thus at level with buildings in framework and mats of mineral wool. The sound insulation ability is also very good.

As a sixth advantage may be mentioned that supply of electrical power if desired may be hidden in the walls.

The production is easy to adapt/ change (tailor-made), whereby an architect-designed cabin or the like is read into a CAD/ CAM software that automatically calculates and initiates production of the correct number and size of numbered constructional elements. Such elements may be delivered as a ready to raise building-kit with an instruction-CD that contains a step-by step explanation of how to best raise the kit.

The properties may be associated with the individual components of a preferred constructional element according to the invention, as follows:

- The side walls are wooden or of a wood-like material that provides the desired look and provides stability in the longitudinal direction of the constructional element while at the same time allowing sufficient hold for nails, screws and the like.
- The plastic material makes the elements diffusion proof, stabilizes the side walls (the boards) in the cross direction and binds the ribs to the boards.
- The ribs provide dimension stability (constant height and curvature) and provides attachment for the attachment means.
- The attachment means decide the thickness of a constructional element and hold together – aided by the pipe elements – pairs of structural elements (side walls) thus forming a constructional element.
- The pipe elements bind together two and two of said structural elements to one constructional element, provide the latter a weight carrying ability and stable height and contribute to guide the constructional elements when assembled to a wall. Subsequent to such assembly the pipe elements form guides for bolts or rods that hold the constructional elements of a wall tightly together.
- Tape or foil strips over and under each element in their longitudinal direction provide a diffusion barrier at these sides of the constructional element.
- Insulating material in the constructional element insulates against temperature and sound.

While the structural elements comprising the visible parts of a constructional element according to the invention are mainly intended for assembly in pairs to such constructional elements as discussed in this description, such structural elements may also be used as for panelling or cleading. For such a purpose it is convenient but not required to provide the side edges with some kind of tongue and groove or the like to ensure a nice and even transition between each of the elements.